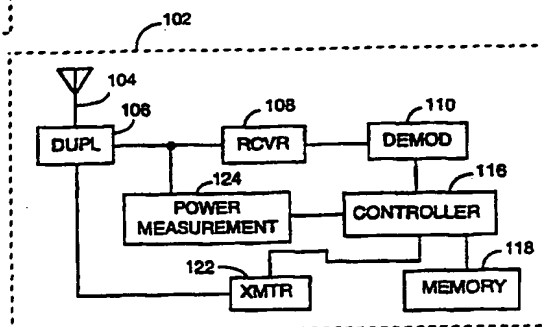
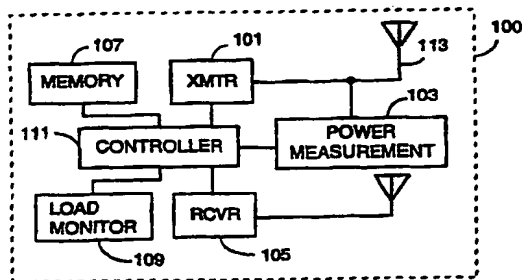




## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<b>(51) International Patent Classification <sup>6</sup>:</b> <b>H04B 7/00</b>	<b>A2</b>	<b>(11) International Publication Number:</b> <b>WO 99/14869</b> <b>(43) International Publication Date:</b> 25 March 1999 (25.03.99)
<b>(21) International Application Number:</b> PCT/US98/19499 <b>(22) International Filing Date:</b> 18 September 1998 (18.09.98) <b>(30) Priority Data:</b> 08/933,889                      19 September 1997 (19.09.97)      US <b>(71) Applicant:</b> QUALCOMM INCORPORATED [US/US]; 6455 Lusk Boulevard, San Diego, CA 92121 (US). <b>(72) Inventor:</b> SOLIMAN, Samir, S.; 11412 Cypress Canyon Park Drive, San Diego, CA 92131 (US). <b>(74) Agents:</b> MILLER, Russell, B. et al.; QUALCOMM Incorporated, 6455 Lusk Boulevard, San Diego, CA 92121 (US).		<b>(81) Designated States:</b> AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, HR, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).  <b>Published</b> <i>Without international search report and to be republished upon receipt of that report.</i>

**(54) Title:** ACCURATE OPEN LOOP POWER CONTROL IN A CODE-DIVISION MULTIPLE ACCESS COMMUNICATION SYSTEM

**(57) Abstract**

A method and system for open loop power control in a CDMA communication system. The method and system control the power of a mobile station (102) transmission signal in a CDMA communication system having a base station (100) which transmits a pilot signal. The method includes calculating, in the base station (100), a base station pilot transmit power value, and a base station receiver (105) sensitivity value. The base station (100) transmits the pilot transmit power value and the receiver (105) sensitivity value to said mobile station. In turn, the mobile station (102) calculates a mean output power in response to the base station pilot transmit power value and the base station receiver (105) sensitivity value.

**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav	TM	Turkmenistan
BF	Burkina Faso	GR	Greece		Republic of Macedonia	TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's	NZ	New Zealand		
CM	Cameroon		Republic of Korea	PL	Poland		
CN	China	KR	Republic of Korea	PT	Portugal		
CU	Cuba	KZ	Kazakhstan	RO	Romania		
CZ	Czech Republic	LC	Saint Lucia	RU	Russian Federation		
DE	Germany	LI	Liechtenstein	SD	Sudan		
DK	Denmark	LK	Sri Lanka	SE	Sweden		
EE	Estonia	LR	Liberia	SG	Singapore		

# ACCURATE OPEN LOOP POWER CONTROL IN A CODE-DIVISION MULTIPLE ACCESS COMMUNICATION SYSTEM

## BACKGROUND OF THE INVENTION

5

### I. Field of the Invention

The present invention relates to digital wireless communication systems. More particularly, the present invention relates to a novel and improved method and apparatus for performing accurate open loop power control in a code-division multiple access (CDMA) communication system.

### II. Description of the Related Art

15 In the field of wireless communications, several technology-based standards exist for controlling communications between a mobile station, such as a cellular telephone, Personal Communication System (PCS) handset, or other remote subscriber communication device, and a wireless base station. These include both digital-based and analog-based standards. For example, among the digital-based cellular standards are the Telecommunications Industry Association/Electronic Industries Association (TIA/EIA) Interim Standard IS-95 series including IS-95A and IS-95B, entitled "Mobile Station - Base Station Compatibility Standard for Dual-Mode Wideband Spread Spectrum Cellular System." Similarly, among the digital-based PCS standards are the American National Standards Institute (ANSI) J-STD-008 series, entitled "Personal Station - Base Station Compatibility Requirements for 1.8 to 2.0 GHz Code Division Multiple Access (CDMA) Personal Communication Systems."

25 The spread spectrum modulation technique of CDMA has significant advantages over other modulation techniques for multiple access communication systems. The use of CDMA techniques in a multiple access communication system is disclosed in U.S. Patent No. 4,901,307, issued February 13, 1990, entitled "SPREAD SPECTRUM MULTIPLE ACCESS COMMUNICATION SYSTEM USING SATELLITE OR TERRESTRIAL REPEATERS", assigned to the assignee of the present invention and incorporated by reference herein.

30 Space or path diversity is obtained by providing multiple signal paths through simultaneous links from a mobile station through two or more cell-sites. Furthermore, path diversity may be obtained by exploiting the multipath environment through spread spectrum processing by allowing a

40

signal arriving with different propagation delays to be received and processed separately. Examples of path diversity are illustrated in U.S. Patent No. 5,101,501, issued March 31, 1992, entitled "SOFT HANDOFF IN A CDMA CELLULAR TELEPHONE SYSTEM", and U.S. Patent No. 5,109,390, issued April 28, 1992, entitled "DIVERSITY RECEIVER IN A CDMA CELLULAR TELEPHONE SYSTEM", both assigned to the assignee of the present invention and incorporated by reference herein.

The deleterious effects of fading can be further controlled to a certain extent in a CDMA system by controlling transmitter power. A system for cell-site and mobile station power control is disclosed in U.S. Patent No. 5,056,109, issued October 8, 1991, entitled "METHOD AND APPARATUS FOR CONTROLLING TRANSMISSION POWER IN A CDMA CELLULAR MOBILE TELEPHONE SYSTEM", also assigned to the assignee of the present invention and incorporated herein by reference. The use of CDMA techniques in a multiple access communication system is further disclosed in U.S. Patent No. 5,103,459, issued April 7, 1992, entitled "SYSTEM AND METHOD FOR GENERATING SIGNAL WAVEFORMS IN A CDMA CELLULAR TELEPHONE SYSTEM", assigned to the assignee of the present invention and incorporated by reference herein.

Fundamental to the concept of cellular or PCS telephony in a CDMA system is the process of power control. A CDMA communication system is an interference limited system in the sense that the system capacity (i.e., the number of simultaneous calls) is a function of the maximum amount of interference that the system can tolerate. The amount of interference depends on the received signal level from each mobile station. The output power of each mobile station must be controlled so as to guarantee enough signal strength received at the base station to maintain good signal quality. The system capacity is maximized if the transmit power of each user is controlled so that the signal power at the cell receiver is the minimum required to achieve a predetermined signal-to-noise ratio (SNR). Hence, to achieve high capacity, the CDMA system employs power control on both forward and reverse links to solve the near-far problem, the corner problem, and long and short term channel variations.

In the open loop power control method according to IS-95, the mobile station uses the measured total received power along with typical values of certain base station parameters to get a rough estimate of the transmission loss between the unit and the base station. Based on these measurements, the forward link transmission loss is estimated and used to determine the proper open loop power control setting for the mobile station transmitter.

The mobile station's transmit power is adjusted to match the estimated path loss, to arrive at the base station at a predetermined level. All mobile stations use the same process, and ideally their signal will arrive with equal power at the base station.

- 5       The base station parameters just mentioned are passed to the mobile station over the paging channel from the base station to the mobile station in an Access Parameters Message, described in detail in section 7.7.2.3.2.2 of IS-95. Of particular importance to the present invention are the fields NOM\_PWR and INIT\_PWR which are contained in the Access Parameters
- 10   Message. The field NOM\_PWR represents a correction factor to be used by the mobile station in its open loop power estimate, and the field INIT\_PWR represents a correction factor to be used by the mobile station in the open loop power estimate for the initial transmission on an access channel.

- 15       The current algorithm for estimating the mobile station's desired transmit power for the first access probe on the access channel is given by:

$$\begin{aligned} \text{Mean Output Power (dBm)} = & -73 - \text{Mean Received Power (dBm)} & (1) \\ & + \text{NOM\_PWR (dB)} \\ & + \text{INIT\_PWR (dB)}. \end{aligned}$$

20

- For subsequent probes on the access channel, each access probe sequence is sent at an increased power level until a response is obtained or the sequence ends. The amount of each increase is set by the field PWR\_STEP, which is also sent in the Access Parameters Message. Then, the initial transmit
- 25   power on the reverse traffic channel is specified to be:

$$\begin{aligned} \text{Mean Output Power (dBm)} = & -73 - \text{Mean Received Power (dBm)} & (2) \\ & + \text{NOM\_PWR (dB)} \\ & + \text{INIT\_PWR (dB)} \\ & + \text{sum of all access probe corrections (dB)}. \end{aligned}$$

30

- The values for NOM\_PWR, INIT\_PWR, and PWR\_STEP are all defined by the base station, and sent to the mobile station prior to the mobile station's first transmission. The nominal value of NOM\_PWR is 0 dB, with
- 35   a range of -8 to 7 dB. The nominal value of INIT\_PWR is also 0 dB with a range of -16 to 15 dB. The range of PWR\_STEP is 0 to 7 dB.

Looking at Equations (1) and (2), one can see that a constant of -73 dB is used as the open loop power control constant. This value is a nominal value which was calculated as follows:

$$C = \frac{E_b}{N_t} + 10 \log(kTR) + F + 10 \log(P_t^c) - 10 \log(1 - x) + 10 \log\left(1 + \sum_{i=1}^{M-1} \zeta_i\right) \quad (3)$$

evaluated at the fixed nominal values of:

$$\frac{E_b}{N_t} = \text{Bit energy to total noise power spectral density} = 7 \text{ dB}$$

10  $k = \text{Boltzmann's constant} = 1.38 \times 10^{-23} \text{ Joule/Kelvin}$

$T = \text{Temperature of the receiver in Kelvin} = 290^\circ \text{ K}$

$R = \text{Data Rate} = 9.6 \text{ Kbps}$

$F = \text{Base station noise figure} = 5 \text{ dB}$

$P_t^c = \text{Total base station transmit power} = 20 \text{ Watts}$

15  $X = \text{Reverse link loading factor} = 50\%$

$M = \text{Equivalent number of cells surrounding the mobile station} = 2$

$\zeta_i = \text{Ratio of power received from cell } i \text{ to power received from mobile station's home cell} = 1.$

20 From the above calculations, it is clear that the value of the open loop power control constant depends on many dynamically varying parameters. For example, the total base station transmit power may vary depending on whether the cell's effective radiation power (ERP) has been recently adjusted. The ratio of power received from cell  $i$  to the power received from the mobile station's home cell may vary depending on the location of the mobile station within the cell. When the mobile station is at the edge of its home cell's coverage, the ratio may increase. Conversely, when it is closer to the center of the home cell, the ratio may decrease. The number of cells surrounding the mobile station is clearly not the same for every cell. Some cells are more remotely located than others and will have fewer surrounding cells. The cell receiver noise figure may change due to maintenance or upgrading of the receiver. The reverse link  $E_b/N_t$  may change simply due to the nature of the dynamic wireless environment.

35 None of these dynamically changing variables is known, a priori, to the mobile station. Hence, the first probe power level will likely be in error because of the use of nominal values rather than actual values in calculating the open loop power control constant. As a result, when the mobile station is close to the base station, it will transmit at far too high of a power level

than necessary to establish communications. To the extent that the transmit power level is too high, it constitutes unnecessary interference to the remaining mobile stations, reducing the capacity of the system. On the other hand, if the mobile station is far away, it may transmit the initial access probe at too low a power level, resulting in additional probes being sent. In addition to increasing call setup time, additional probes will result in more reverse link interference. What is needed is an improved method and apparatus for performing accurate open loop power control in a code-division multiple access (CDMA) communication system, which will increase the probability of successful completion of the first access probe and hence decrease the amount of reverse link interference.

### SUMMARY OF THE INVENTION

The present invention is a novel and improved method and system for open loop power control in a CDMA communication system. The method and system controls the power of a mobile station transmission signal in a CDMA communication system having a base station which transmits a pilot signal. The method includes calculating, in the base station, a base station pilot transmit power value, and a base station receiver sensitivity value. The base station transmits the pilot transmit power value and the receiver sensitivity value to said mobile station. In turn, the mobile station calculates a mean output power in response to the base station pilot transmit power value and the base station receiver sensitivity value.

In order to calculate the mean output value, a power measurement circuit in the mobile station measures a total received power and a demodulator in the mobile station, for measures a signal to noise ratio of said pilot signal. A mobile station controller then calculates a forward link path loss in response to the pilot transmit power value, the total received power, the said signal to noise ratio. In the preferred embodiment, the signal to noise ratio is a ratio of energy per chip to total power spectral density of the pilot signal.

In order for the base station to determine the receiver sensitivity, a load monitor calculates a loading factor in response to a number of simultaneous calls currently being serviced by the base station. The base station receiver noise figure is stored in a memory element in the base station. A receiver in the base station determines an access channel ratio of energy per bit to total noise power spectral density. With this information, a base station controller calculates the base station receiver sensitivity value in

response to the loading factor, the base station receiver noise figure, and the access channel ratio of energy per bit to total noise power spectral density.

## BRIEF DESCRIPTION OF THE DRAWINGS

5

The features, objects, and advantages of the present invention will become more apparent from the detailed description set forth below when taken in conjunction with the drawings in which like reference characters identify correspondingly throughout and wherein:

10 FIG. 1 is an illustration of the system of the present invention in block diagram format; and

FIG. 2 is a flowchart of the method of the present invention as executed by the system of FIG. 1.

15

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIG. 1, a block diagram of the system of the present invention is illustrated. Base station 100 is a CDMA base station which  
20 transmits a pilot channel as is known in the art and described further in IS-95. Base station 100 also transmits one or more traffic channels as are known in the art and further described in IS-95. Base station 100 also receives incoming CDMA signals transmitted by one or more mobile stations 102. Mobile station 102 is an off-the-shelf CDMA mobile station as is  
25 known in the art, and operates substantially according to IS-95 or one of the other CDMA standards including ANSI J-STD-008, with the exception of the open loop power control described herein.

Upon initialization, mobile station 102 seeks to acquire the pilot signal having the strongest received energy. The pilot signal transmitted,  
30 for example, by base station 100 is captured by antenna 104 of mobile station 102, and routed via duplexer 106 to receiver (RCVR) 108. Receive power measurement circuit 124, as part of the AGC system in mobile station 102, measures the total in-band power incident at receiver 108 and passes that total power measurement to mobile station controller 116. More details on  
35 AGC in power control can be found in the above-mentioned U.S. Patent No. 5,056,109.

Receiver 108 downconverts the received pilot signal, and passes it to demodulator (DEMODO) 110. Demodulator 110 digitally demodulates the received pilot signal as is known in the art and described in the above-



referenced patents and measures the energy per chip to total power spectral density ( $E_c/I_0$ ) of the demodulated pilot signal, and passes that  $E_c/I_0$  to mobile station controller 116.

Once the pilot signal is successfully demodulated in demodulator 110, mobile station 102 has an accurate coherent demodulation reference and is capable of demodulating the sync channel in order to obtain the timing of the base station's 100 pilot PN sequence with respect to system time and the paging channel data rate. Once the mobile station 102 has obtained information from the sync channel, it adjusts its timing to correspond to that of the base station 100, and begins to monitor its assigned paging channel.

As discussed above, one of the overhead messages carried on the paging channel is the Access Parameters Message. However, in the present invention, base station 100 does not send the Access Parameters Message exactly as it is described in section 7.7.2.3.2.2 of IS-95. In the present invention, the fields NOM\_PWR and INIT\_PWR are not sent. Instead, base station 100 sends a modified access parameters message in which two different fields, defined herein as PILOT\_PWR and RCVR\_SENS, and described further below are sent.

The field PILOT\_PWR is defined as the transmit power, as measured by power measurement circuit 103 at the output of the base station transmitter 101, of the pilot signal. RCVR\_SENS is proportional to the minimum power necessary for the base station receiver 105 to detect the signal. In a CDMA system, this is the sum of loading factor, base station receiver 105 noise figure, and an estimate of the access channel ratio of energy per bit to total noise power spectral density  $E_b/N_t$ , all in units of dB.

The base station noise figure is a calibrated value which is stored in the base station memory 109 at the time of installation of the base station receiver 105, or during change of the base station receiver 105 configuration. Base station controller 111 reads the stored noise figure value from base station memory 109. The base station receiver 105 provides controller 111 with the access channel  $E_b/N_t$  during demodulation of the access channel. Specifically, a channel demodulating element (not shown) within receiver 105 calculates the access channel  $E_b/N_t$  as is known in the art. The loading factor is measured by load monitor 109 and provided to base station controller 111. Loading factor is a function of the number of simultaneous calls currently in progress and the total number of simultaneous calls that the base station 100 has the capacity to handle. For example, the loading factor may be measured in the manner described in further detail in

compending U.S. Patent Application Serial No. 08/688,453, filed July 30, 1996, entitled "LOAD MONITORING AND MANAGEMENT IN A CDMA WIRELESS COMMUNICATION SYSTEM," assigned to the assignee of the present invention and incorporated herein by reference.

5        With the above information, base station controller 111 calculates the fields PILOT\_PWR and RCVR\_SENS. The base station then transmits these fields to the mobile station 102 as part of the modified access parameters message. These fields PILOT\_PWR and RCVR\_SENS enable mobile station 102 to calculate a better estimate of the initial transmit power to be used on  
10    the access channel when transmitting access probes.

      It should be noted that the present invention is not limited by the exact format of IS-95 messages, but is broadly applicable to any communication system in which the actual pilot transmit power and receiver sensitivity are sent to the mobile station. However, the phrase  
15    "modified access parameters message" will be used herein for convenience in referring to the message sent by the base station which includes the actual pilot transmit power and receiver sensitivity.

      The mobile station 102 receives the modified access parameters message while monitoring its assigned paging channel. Demodulator 110  
20    demodulates the modified access parameters message and passes the demodulated data to mobile station controller 116. Mobile station controller 116 parses the demodulated modified access parameters message data and extracts and stores the values for PILOT\_PWR and RCVR\_SENS in memory 118.

25        When it is necessary for mobile station 102 to send a message on the access channel, such as in order to initiate a call origination or perform a registration, mobile station controller 116 calculates the proper initial access probe power level to be used by transmitter 122. In order to calculate the proper initial access probe power level, mobile station controller 116  
30    determines the forward link path loss. The forward link path loss is defined as the forward link transmission loss minus the gain of the base station antenna 113 and the gain of the mobile station antenna 104 relative to half-wave dipole antennas (including cable losses). The forward link transmission loss is the ratio of the output power of the base station  
35    transmitter 101 to the total power received at the termination of the receiving antenna 104 of mobile station 102. Since the pilot channel is always transmitted by base station transmitter 101 at a constant power level, the received pilot power can be used to measure the forward link

transmission loss. In mathematical terms, the transmission loss is expressed as:

$$T(d) = 10 \log \frac{P'_p(d)}{P'_p} \quad (4)$$

and therefore the path loss is:

$$L(d) = 10 \log \frac{P'_p(d)}{P'_p} - G_x - G_r \quad (5)$$

where:

$P'_p(d)$  = the received pilot power at a distance,  $d$ , from the transmitter 101;

$P'_p$  = the transmitted pilot power at the base station transmitter 101 output;

$G_x$  = the gain of the transmitting antenna 113 in dB relative to a half-wave dipole; and

$G_r$  = the gain of the receiving antenna 104 in dB relative to a half-wave dipole.

Thus, in order to estimate the forward link path loss, the mobile station controller 116 needs to know only the transmitted and received pilot powers. The transmitted pilot power, PILOT\_PWR as described above, is sent on the paging channel as part of the modified access parameters message. The received pilot power is estimated by mobile station controller 116 by using the measured  $E_c/I_0$  (signal to noise ratio) of the received pilot as measured by demodulator 110 and the total received power as measured by receive power measurement circuit 124, according to the following relationship:

$$P'_p(d) = P'_r \frac{E_c}{I_0} \quad (6)$$

where:

$P'_r$  = the total received power as measured by receive power measurement circuit 124.

With this information, mobile station controller 116 has sufficient information to calculate the forward link path loss as:

$$L_f(d) = P'_r - P'_p \quad (7)$$

Mobile station controller 116 also calculates the base station receiver sensitivity as:

$$S=10\log(kTR)+RCVR\_SENS. \quad (8)$$

Note that the value  $10\log(kTR)$ , which is the thermal noise floor at the data rate  $R$ , may also be included in the value of  $RCVR\_SENS$  if known by the base station 100, or alternately, the mobile station may use assumed values for  $T$ , the temperature, and  $R$ , the data rate.

Knowing the forward link path loss from equation (7) above, and the receiver sensitivity from equation (8) above, mobile station controller 116 can then calculate the mobile station transmit power necessary to arrive at base station receiver 105 with the minimum detectable level, thereby minimizing interference to other users while still ensuring adequate reception. The access probe is transmitted by transmitter 122 at a mean output power defined by:

$$\text{Mean output power (dBm)} = S - L_f(d). \quad (9)$$

The method executed by the system of FIG. 1 described above is illustrated in FIG. 2. The process begins at block 200 where base station 100 calculates the two fields,  $PILOT\_PWR$  and  $RCVR\_SENS$  as described above. In block 202, base station 202 sends  $PILOT\_PWR$  and  $RCVR\_SENS$  to mobile station 102. At block 204, mobile station 102 receives, demodulates, and stores  $PILOT\_PWR$  and  $RCVR\_SENS$ . At block 206, mobile station controller 116 calculates the forward link path loss as described above with reference to equation (7). At block 208, mobile station controller 116 calculates the base station receiver sensitivity as described above with reference to equation (8). Then, at block 210 mobile station 102 transmits an access probe at the mean output power calculated in accordance with equation (9).

The present invention may also be expressed in terms analogous to the expressions for mean output power that are described in IS-95. Specifically, according to the present invention, the following changes may be made to IS-95:

(1) For the first probe:

$$\begin{aligned} \text{mean output power (dBm)} = & -174 + \\ & - \text{mean input power (dBm)} \\ & + \text{serving pilot (dB)} \\ & + \text{PILOT\_PWR (dBm)} \\ & + \text{RCVR\_SENS (dB)}; \end{aligned}$$

where is the access channel fixed data rate (4.8 kbps) and is the pilot strength of the serving sector.

(2) For subsequent probes, the access probe sequence are sent at increased power levels (each probe is incremented by a value equal to PWR\_STEP) until a response is obtained or the sequence ends (see IS-95 section 6.6.3.1).

(3) The initial transmission on the Reverse Traffic Channel is at a mean output power defined by:

$$\begin{aligned} \text{mean output power (dBm)} = & -174 + \\ & - \text{mean input power (dBm)} \\ & + \text{serving pilot (dB)} \\ & + \text{PILOT\_PWR (dBm)} \\ & + \text{RCVR\_SENS (dB)} \\ & + \text{the sum of all access probe corrections (dB)}; \end{aligned}$$

where is the traffic channel data rate (either 9.6 or 14.4 kbps) and is the strength of the reference pilot.

(4) Once the first power control bit has been received after initializing Reverse Traffic Channel transmissions, the mean output power is defined by:

$$\begin{aligned} \text{mean output power (dBm)} = & -174 + \\ & - \text{mean input power (dBm)} \\ & + \text{serving pilot (dB)} \\ & + \text{PILOT\_PWR (dBm)} \\ & + \text{RCVR\_SENS (dB)} \\ & + \text{the sum of all access probe corrections (dB)} \\ & + \text{the sum of all closed loop power control corrections (dB)}. \end{aligned}$$

Thus, the present invention provides a novel and improved method and system for open loop power control in a CDMA communication system. The present invention overcomes the problems associated with transmitting the first access probe at a nominal power level. Unnecessary  
5 interference is reduced, while at the same time increasing the probability of successful reception of the first access probe at the base station by using more accurate determinations of pilot transmit power and receiver sensitivity.

The previous description of the preferred embodiments is provided to enable any person skilled in the art to make or use the present invention.  
10 The various modifications to these embodiments will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other embodiments without the use of the inventive faculty. Thus, the present invention is not intended to be limited to the embodiments shown herein but is to be accorded the widest scope consistent  
15 with the principles and novel features disclosed herein.

I CLAIM:

## CLAIMS

1. A method for controlling the power of a mobile station  
2 transmission signal in a CDMA communication system having a base  
station which transmits a pilot signal, the method comprising the steps of:  
4 calculating, in said base station, a base station pilot transmit power  
value;  
6 calculating, in said base station, a base station receiver sensitivity  
value;  
8 transmitting said pilot transmit power value and said receiver  
sensitivity value to said mobile station; and  
10 calculating, in said mobile station, a mean output power in response  
to said base station pilot transmit power value and said base station receiver  
12 sensitivity value.

2. The method of claim 1 wherein said step of calculating a mean  
2 output power further comprises the steps of:  
measuring, in said mobile station, a total received power;  
4 measuring, in said mobile station, a signal to noise ratio of said pilot  
signal; and  
6 calculating a forward link path loss in response to said pilot transmit  
power value, said total received power, and said signal to noise ratio.

3. The method of claim 2 wherein said signal to noise ratio is a  
2 ratio of energy per chip to total power spectral density of said pilot signal.

4. The method of claim 2 further comprising the step of storing  
2 said base station pilot transmit power value and said base station receiver  
sensitivity value in said mobile station.

5. The method of claim 2 wherein said step of calculating said  
2 base station receiver sensitivity value further comprises the steps of:  
calculating a loading factor in response to a number of simultaneous  
4 calls currently being serviced by said base station;  
determining a base station receiver noise figure;  
6 determining an access channel ratio of energy per bit to total noise  
power spectral density; and

8 calculating said base station receiver sensitivity value in response to  
said loading factor, said base station receiver noise figure, and said access  
10 channel ratio of energy per bit to total noise power spectral density.

6. A system for controlling the power of a mobile station  
2 transmission signal in a CDMA communication system having a base  
station which transmits a pilot signal, the system comprising:

4 a base station controller in said base station, for calculating a base  
station pilot transmit power value and a base station receiver sensitivity  
6 value;

a base station transmitter for transmitting said pilot transmit power  
8 value and said receiver sensitivity value to said mobile station; and

a mobile station controller in said mobile station, for calculating a  
10 mean output power in response to said base station pilot transmit power  
value and said base station receiver sensitivity value.

7. The system of claim 6 further comprising:

2 a power measurement circuit in said mobile station, for measuring a  
total received power; and

4 a demodulator in said mobile station, for measuring a signal to noise  
ratio of said pilot signal;

6 and wherein said mobile station controller calculates a forward link  
path loss in response to said pilot transmit power value, said total received  
8 power, and said signal to noise ratio.

8. The system of claim 7 wherein said signal to noise ratio is a  
2 ratio of energy per chip to total power spectral density of said pilot signal.

9. The system of claim 7 further comprising a memory element in  
2 said mobile station for storing said base station pilot transmit power value  
and said base station receiver sensitivity value.

10. The system of claim 7 further comprising:

2 a load monitor, for calculating a loading factor in response to a  
number of simultaneous calls currently being serviced by said base station;

4 a memory element in said base station, for storing a base station  
receiver noise figure; and

6 a receiver in said base station, for determining an access channel ratio  
of energy per bit to total noise power spectral density;



8            wherein said base station controller calculates said base station  
receiver sensitivity value in response to said loading factor, said base station  
10 receiver noise figure, and said access channel ratio of energy per bit to total  
noise power spectral density.

1/2

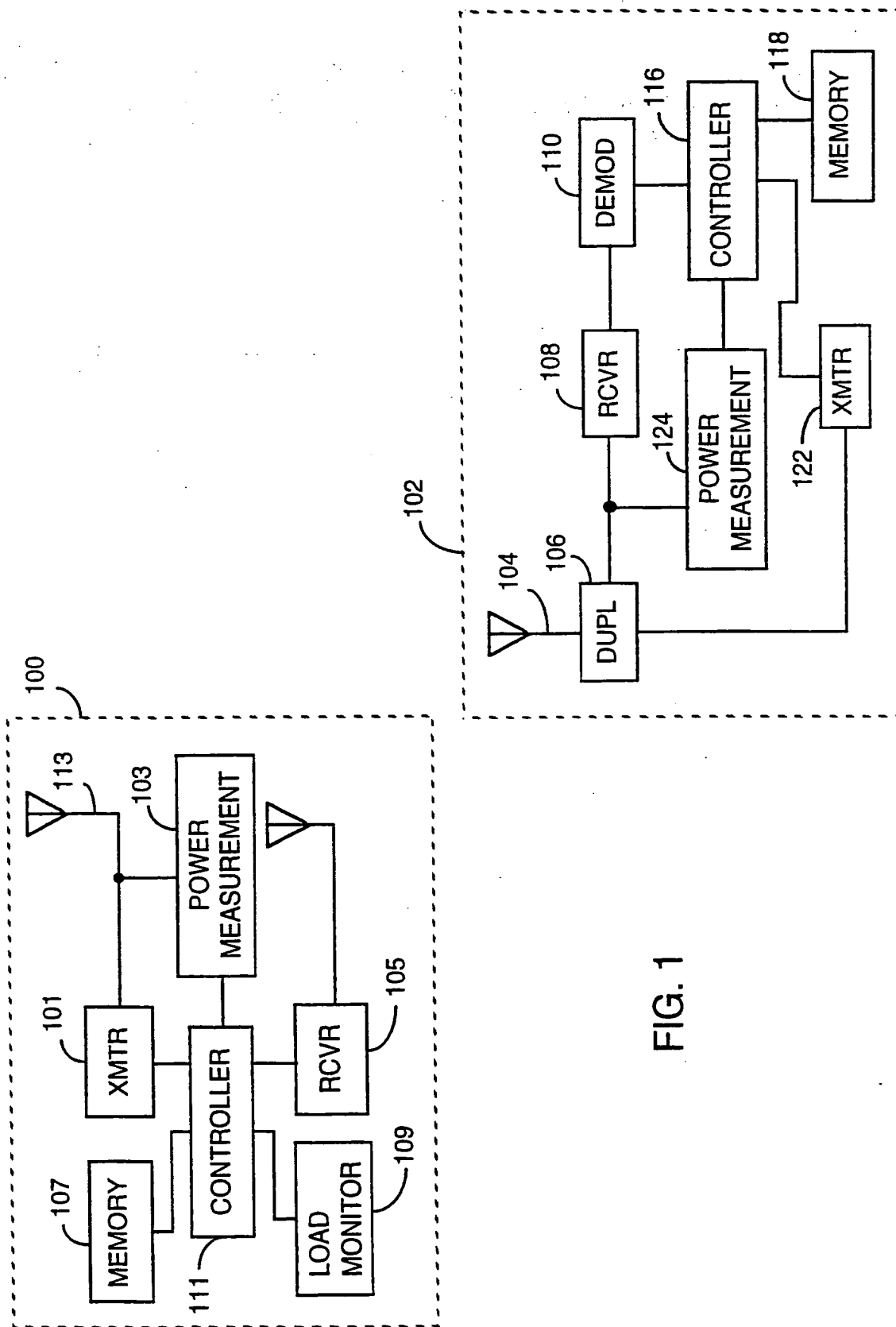


FIG. 1

2/2

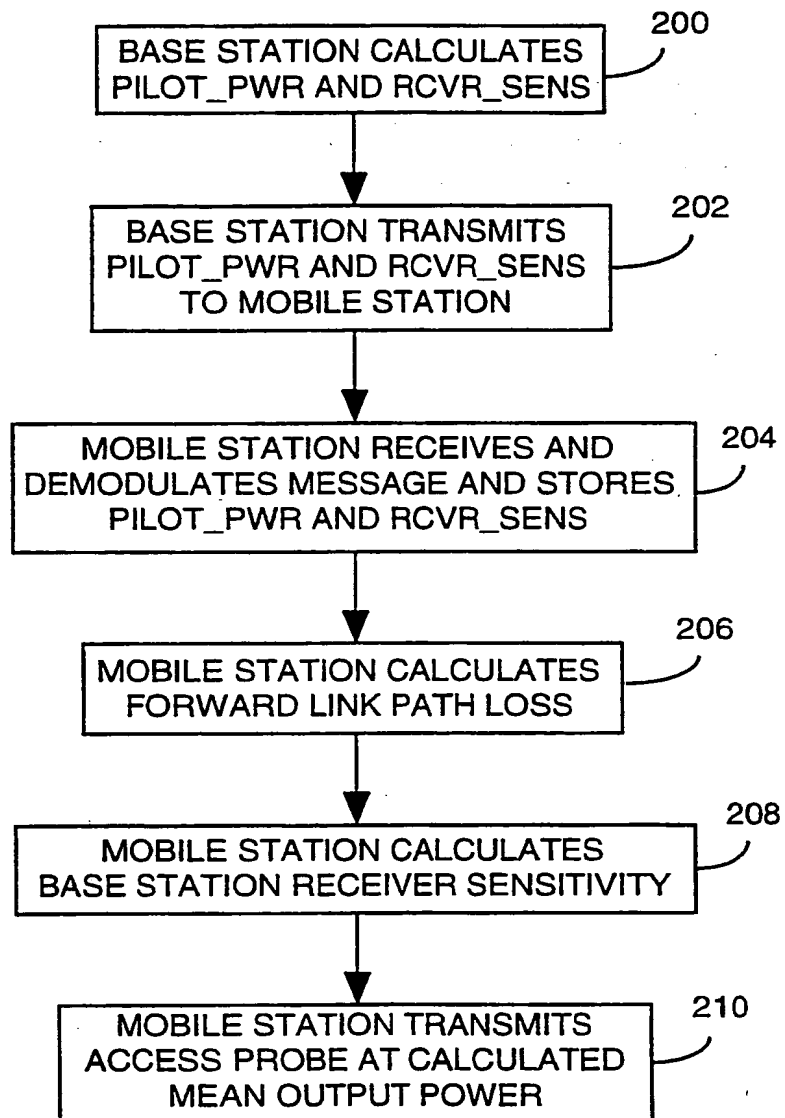


FIG. 2

1/2

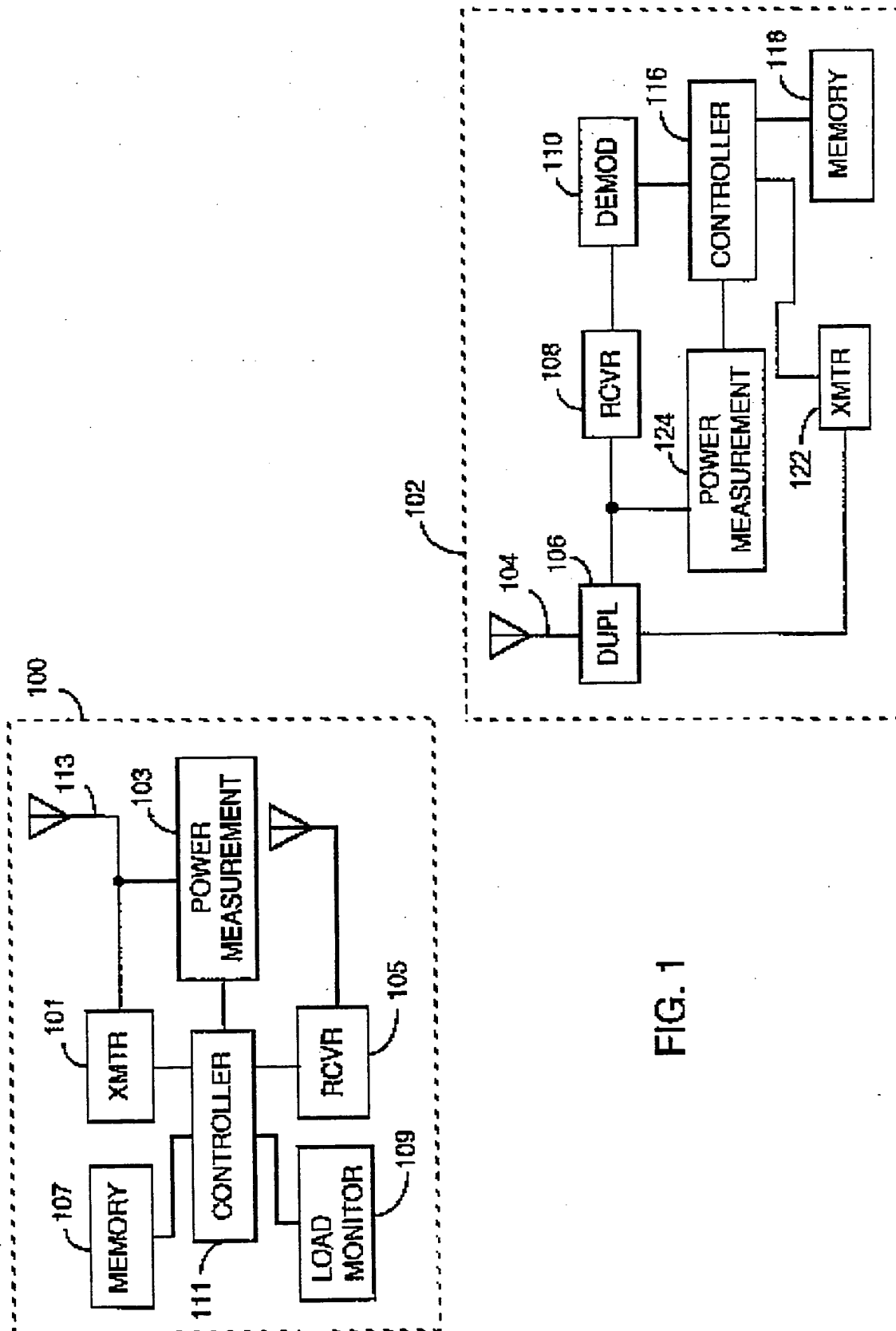


FIG. 1

2/2

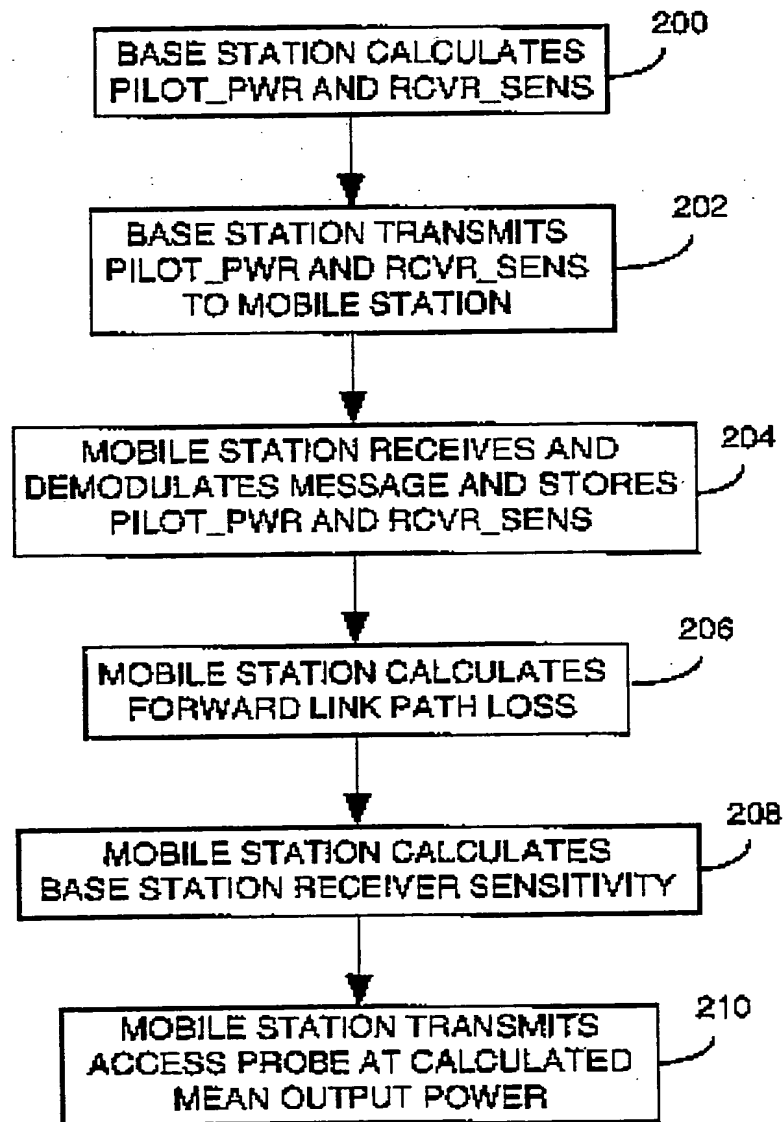


FIG. 2



## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification <sup>6</sup> :

H04B 7/005

A3

(11) International Publication Number:

WO 99/14869

(43) International Publication Date:

25 March 1999 (25.03.99)

(21) International Application Number: PCT/US98/19499

(22) International Filing Date: 18 September 1998 (18.09.98)

(30) Priority Data:

08/933,889

19 September 1997 (19.09.97) US

(71) Applicant: QUALCOMM INCORPORATED [US/US]; 6455 Lusk Boulevard, San Diego, CA 92121 (US).

(72) Inventor: SOLIMAN, Samir, S.; 11412 Cypress Canyon Park Drive, San Diego, CA 92131 (US).

(74) Agents: MILLER, Russell, B. et al.; QUALCOMM Incorporated, 6455 Lusk Boulevard, San Diego, CA 92121 (US).

(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, HR, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

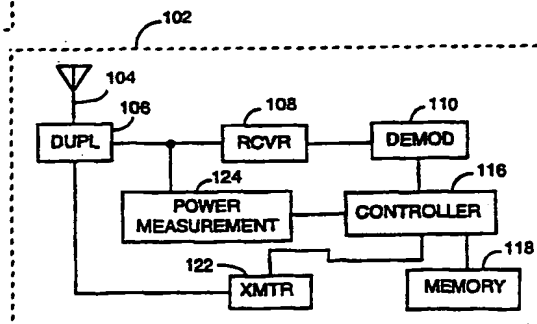
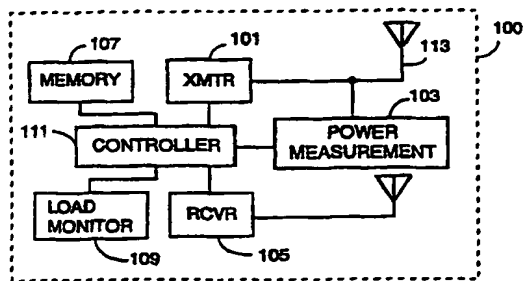
## Published

*With international search report.**Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.*

(88) Date of publication of the international search report:

3 June 1999 (03.06.99)

(54) Title: ACCURATE OPEN LOOP POWER CONTROL IN A CODE-DIVISION MULTIPLE ACCESS COMMUNICATION SYSTEM



## (57) Abstract

A method and system for open loop power control in a CDMA communication system. The method and system control the power of a mobile station (102) transmission signal in a CDMA communication system having a base station (100) which transmits a pilot signal. The method includes calculating, in the base station (100), a base station pilot transmit power value, and a base station receiver (105) sensitivity value. The base station (100) transmits the pilot transmit power value and the receiver (105) sensitivity value to said mobile station. In turn, the mobile station (102) calculates a mean output power in response to the base station pilot transmit power value and the base station receiver (105) sensitivity value.

**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Larvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece	ML	Mali	TR	Turkey
BG	Bulgaria	HU	Hungary	MN	Mongolia	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MR	Mauritania	UA	Ukraine
BR	Brazil	IL	Israel	MW	Malawi	UG	Uganda
BY	Belarus	IS	Iceland	MX	Mexico	US	United States of America
CA	Canada	IT	Italy	NE	Niger	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NL	Netherlands	VN	Viet Nam
CG	Congo	KE	Kenya	NO	Norway	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NZ	New Zealand	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	PL	Poland		
CM	Cameroon	KR	Republic of Korea	PT	Portugal		
CN	China	KZ	Kazakstan	RO	Romania		
CU	Cuba	LC	Saint Lucia	RU	Russian Federation		
CZ	Czech Republic	LI	Liechtenstein	SD	Sudan		
DE	Germany	LK	Sri Lanka	SE	Sweden		
DK	Denmark	LR	Liberia	SG	Singapore		
EE	Estonia						

# INTERNATIONAL SEARCH REPORT

Interr.      nal Application No

PCT/US 98/19499

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 6      H04B7/005

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6      H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	SAMIR SOLIMAN ET AL: "CDMA REVERSE LINK OPEN LOOP POWER CONTROL" COMMUNICATION FOR GLOBAL USERS, INCLUDING A COMMUNICATIONS THEORY MINI CONFERENCE ORLANDO, DEC. 6 - 9, 1992, vol. 1, 6 December 1992, pages 69-73, XP000357763 INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS	1-3,6-8
A	see abstract see page 70, left-hand column, line 7-13 see page 70, right-hand column, line 1 - page 72, left-hand column, line 30 see page 72, left-hand column, line 35-42 --- -/--	4,5,9,10

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

"Special categories of cited documents:

"A" document showing the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

29 March 1999

Date of mailing of the international search report

07/04/1999

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,  
Fax: (+31-70) 340-3016

Authorized officer

Dejonghe, 0



## INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 98/19499

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5 056 109 A (GILHOUSEN KLEIN S ET AL) 8 October 1991 cited in the application	1-3,6-8
A	see column 1, line 47-60 see column 4, line 64 - column 5, line 20 see column 6, line 28-61 see column 8, line 44-52 see column 10, line 17-29 see column 13, line 45 - column 14, line 41 see column 15, line 51-59 see figure 4 see claims	4,5,9,10
A	--- US 5 469 471 A (WHEATLEY III CHARLES E) 21 November 1995 see column 6, line 56 - column 7, line 33 see figures 3,4 see claims -----	1-10

# INTERNATIONAL SEARCH REPORT

Information on patent family members

Inter. Appl. Application No

PCT/US 98/19499

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5056109 A	08-10-1991	AT 163822 T	15-03-1998
		AU 646001 B	03-02-1994
		AU 6728390 A	31-05-1991
		CA 2072989 A	08-05-1991
		CN 1053870 A,B	14-08-1991
		CN 1090107 A,B	27-07-1994
		CN 1159720 A	17-09-1997
		DE 69032105 D	09-04-1998
		DE 69032105 T	08-10-1998
		EP 0500689 A	02-09-1992
		ES 2113862 T	16-05-1998
		FI 922083 A	07-05-1992
		GR 3026454 T	30-06-1998
		IL 96218 A	27-02-1994
		JP 2776632 B	16-07-1998
		JP 4502841 T	21-05-1992
		MX 172367 B	14-12-1993
		NO 304206 B	09-11-1998
		SG 48360 A	17-04-1998
		WO 9107037 A	16-05-1991
		US 5485486 A	16-01-1996
		US 5265119 A	23-11-1993
		US 5257283 A	26-10-1993
		US 5267262 A	30-11-1993
US 5469471 A	21-11-1995	AU 681771 B	04-09-1997
		AU 1836995 A	21-08-1995
		BR 9505642 A	09-01-1996
		CA 2158157 A	10-08-1995
		CN 1123073 A	22-05-1996
		EP 0692162 A	17-01-1996
		FI 954617 A	28-11-1995
		IL 112487 A	30-10-1998
		JP 8508871 T	17-09-1996
		WO 9521494 A	10-08-1995
		ZA 9500600 A	07-02-1996

**This Page is Inserted by IFW Indexing and Scanning  
Operations and is not part of the Official Record**

**BEST AVAILABLE IMAGES**

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☐ BLACK BORDERS
- ☐ IMAGE CUT OFF AT TOP, BOTTOM OR SIDES
- ☒ FADED TEXT OR DRAWING
- ☐ BLURRED OR ILLEGIBLE TEXT OR DRAWING
- ☐ SKEWED/SLANTED IMAGES
- ☐ COLOR OR BLACK AND WHITE PHOTOGRAPHS
- ☐ GRAY SCALE DOCUMENTS
- ☐ LINES OR MARKS ON ORIGINAL DOCUMENT
- ☐ REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY
- ☐ OTHER: \_\_\_\_\_

**IMAGES ARE BEST AVAILABLE COPY.**

**As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.**